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INCENTIVES FOR MAINTENANCE

by

H. B. Maynard and Company
Denmark

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0. INTRODUCTION

An Incentive (I) is something that incites to action - stimulates and motivates man and mankind to perform, e g to turn out more and better work. This paper deals with Incentives for Maintenance (M), in particular industrial M as applied in manufacturing and service industries.

The basic function of M is to keep plant, machinery and equipment in a condition that will meet normal operating requirements. There are many sub-functions within M, e g M Inspection, Preventive M, Corrective M, Breakdown M and Overhaul. And these sub-functions can again be devided in sub-sub-functions which furthermore can be looked upon from a technological as well as an organizational angle. Other papers deal with these functions and subjects in detail.

In order to discuss I for M it is, however, necessary to have a clear picture of the many components and facets of M. We must know where we are, and where we want to move. We must know what can, and should, be accomplished through the introduction of improved technological and organizational methods and techniques and we must know where the introduction and up-keep of the improved methods and techniques can be supported through I. And we must have a base from where to measure the performance in order to calculate the renumeration or reward for the extra efforts applied.

We must also know what motivates man. Some motivational factors are universal while some vary from country to country, depending on social conditions and cultural heritage.

The installation of a sound incentive system involves many applied sciences such as engineering, administration, sociology and pshychology.

M is not a function that can, or should, be looked upon in splendid isolation. M's performance depends heavily on other functions within an enterprise, in particular Production and Procurement. And first and foremost performance depends on the attitude and outlook of top-management and its ability to organize and administer all functions within the enterprise in a balanced and well co-ordinated manner.

I for M at the plant level is not the first or even one of the first tools to use to improve the M situation within an enterprise. There are many pre-requisites that have to be met before we should think of introducing I for M, pre-requisites which by themselves will assist in improved M.

1. THE DUAL ASPECTS OF M

As already mentioned earlier, M can be looked upon in a number of ways. Two aspects appear to be of particular significance:

1. M as a function that keeps machinery and equipment down-time below desired levels.

2. M as an indirect cost element that increases product price without adding to its value.

It is tempting to overemphasize the first one in order to achieve a low level of machinery and equipment down-time. This is in the interests of the operating departments although it may result in increased M costs.

Increased M costs will attract the eye of the cost control department and efforts are likely to be initiated to reduce the M costs. This may result in less M work which again may result in more break-downs and less availability of machinery and equipment - the operating department will suffer and output will decrease.

It is up to top-management of an enterprise to keep a happy balance between the two opposing M aspects.

M work can, as any other work, be organized according to good industrial management principles and practices. But the organization of M can also be faced with an almost impossible task, namely if the machinery and equipment is not suited for the production, not suited for the operators that attend to it and not suited for the environment in which it works. Any machinery and equipment is designed to function under certain conditions. It is up to those who plan the factory and order the machinery and equipment to consider these factors carefully. And it is up to top-management - and perhaps Government officials, in particular in developing countries - to control that it is done.

The cost of production facilities and their contribution to the manufacturing costs should not just be based upon the purchase price of the facilities. How many years will it be usable? What is required every year to keep it in desired operating condition? What will this cost in

respect of M labour, material and overhead? These costs must be estimated and added to the purchase price. And we may find that the equipment with the lowest price may not be the equipment that generates the lowest over-all cost.

It is much easier to prepare for a good M system when the enterprise is at the planning stage than when it has started production. And it will be much easier to install an I system that will assist management's efforts to keep actual operating results in line with the original plans.

2. M IN RETROSPECT

The history of organized M is short. It is only within the last couple of decades that advanced management principles have been applied to M in enterprises in the industrialized countries.

The need for managing M more effectively is caused by several reasons, some of which are:

1. Introduction of more and more sophisticated equipment requiring higher and higher skilled craftsmen for M.
2. Limited supply of skilled craftsmen with required qualifications.
3. Rapidly increasing wages for the craftsmen.

The sophisticated manufacturing equipment was introduced partly as a result of the incessantly accellerating technological development and partly because of the need to offset increased labour wages and shortage of labour.

This resulted in an unfavourable trend in the number and cost of M-workers to production workers. Equipment down-time tended to go up because of a shortage and subsequent high turnover of M-workers. Management was forced to do something - and they did it.

Industrial Engineering principles were applied to M and gradually modified to suit the particular needs and problems of M. To begin with the aim was mainly to optimize the quality of M services and minimize the M costs. Later on a more over-all and broadminded approach has come into the picture. This development has recently been further aggregated because of the approach to M problems as they appear in military systems, x) where M factors like Reliability and Availability of equipment in many cases may be a question of survival or not. Although this criteria may be the best incentive for man and mankind to do something constructively, it falls outside the scope of this paper. But the achievements will undoubtably make their impact felt even in the design of industrial machinery and equipment in the future.

Effective administration of M activities can only be exercised through sound application of three wellknown elements of scientific management:

1. Organization
2. Measurement
3. Control

Experience from industries in Europe and North America shows that it is possible to reduce M costs from 15 - 45 % and at the same time

increase the availability of machinery and equipment (reduce down-time). What can the developing countries learn from this experience?

The following is an attempt to describe the experience of I for M in industrialized countries so it can serve as foundation for a discussion on what industries in developing countries can apply. And in this connection it should not be forgotten that industries in developing countries are not something uniform or standardized. One can find industries where everything from equipment to management is at par with similar enterprises in the old industrialized countries. But one can also find industries of a very low standard. Most are somewhere inbetween.

3. PRE-REQUISITES FOR OPTIMIZATION OF M EFFORTS

Before we can think of optimizing M efforts through the introduction of various forms of incentives at the plant level, a number of pre-requisites have to be met.

M must function within a well defined organizational structure. An appropriate flow of information and data on M must be designed. Proper planning, scheduling and control of M must be introduced. Supply of spare parts and material must be properly arranged. M manpower must be brought up to a specified level of competence. The M workshops must have a layout that satisfies the needs for repair and overhaul, and the bulk of the working methods must be standardized according to the best principles of work simplification.

Organizational structure

The organizational structure within the M department and between M and other departments is an extremely important pre-requisite for successful M operations. A successful structure in one company will, however, not necessarily suit another company. It must be taylor made in each case. Some rules can, however, be given.

Aims and objectives for the M department must be defined. A possible set of objectives would be to:

- Minimize lost production time due to M.
- Reduce M costs and achieve the best use of money spent.
- Optimize use of M manpower, tools, equipment and materials.
- Improve M in the broadest sense - including both the technical aspects and the service given to the production department.
- Achieve better management control of quality, time used and material concerned.

Definite lines of authority and responsibility must be established for the M department(s) and other departments concerned with M in any way.

The internal M organizational structure can be designed accdording to two basic concepts: centralized and de-centralized M. In the centralized case all requests go to a central M-planning function and from there to a suitable M team. In the de-centralized case all major production departments have been assigned M crews to fit their needs in

terms of specialization and volume of work. In almost every case, when the de-centralized concept is used, there should be a central group responsible for administration, stores, machining operations and levelling of work between the de-centralized groups.

Which concept is to be preferred? This will depend on local conditions and problems, in particular:

- Type of operation. If M chiefly is restricted to a few fields of operation, (process piping, electrical equipment) the character of the work and the amount and type of supervision will be affected.

- Geographical situation and size of plant. One type of organization is more effective in a compact plant while another may be more suitable when operations are spread over a vast area. If the plant is very big, highly specialized work forces should be considered in some fields.

- Scope of the M Operations. Should M not only maintain the equipment, but also assist and perhaps be responsible for construction work as well as installation and renovation of machinery and equipment, the scope of the organization should be wide enough to handle these more varied activities. This is especially the case when project administration is applied.

3.2 Flow of information and data

No M work can proceed effectively in the long run without some type of an information system. The purpose of such a system is:

- to handle the routine flow of requests for work, work orders and material requisitions through the M organization,
- to collect information for management purposes,
- to distribute impulses from management.

To cover these activities there must as a back-bone be some sort of a work request and work order system with a material requisition sub-system. This system is also used to give management necessary control and guidance information. See appendix 1.

The M information system helps everybody concerned within production and maintenance as well as higher management to obtain systematic ansers to the following questions:

1. Before the job is performed

   - What work needs to be done? In what order of priority?
   - What crafts from what area should do the work?
   - When should the work be done?
   - How long should it take?
   - What will it cost?
   - What methods should be used?
   - What materials and what quantities are needed?
   - Do we have too much, the right amount, or not enough manpower?

2. While the work is in progress

- Are we keeping up with our schedule?
- Are we doing the work that we do, when we should do it?
- Are we using the proper methods to do the work?

3. After the work has been completed

- Did we do the work on time?
- Did we meet our labour/material estimates?
- How effective was our M-force? Emergencies versus routine jobs? Utilization?
- How can we further improve our M operations?

The questions sound simple - and so are the answers, if we have the appropriate information system.

In large enterprises the flow of information and data is of such a magnitude that the cost of computorizing the flow may well pay off within one year or so. The reason for this is that the speed with which cost control, planning and scheduling can be accomplished will result in additional savings. There are such systems readily available as computor software packages, covering virtually all information needed within a M organization.

3.3 Planning, Scheduling and Control

The purpose of M planning (How a job is to be done) and scheduling (When a job is to be done) is to define the objectives and content of a

job and then get the right men and facilities, at the right place at the right time. A well designed and well functioning planning and scheduling system will:

1. Reduce delays caused by lack of coordination between production and M schedules.

2. Reduce wasted manpower by eliminating unnecessary travel time for tools and materials needed.

3. Reduce labour charges to a minimum by proper manning for each job. If a job is a one-man job, it should be carried out by one man.

4. Coordinate multi-craft jobs so that delays created by crafts waiting for other crafts to finish up are minimized.

5. Reduce waiting time between jobs because the next order is already prepared.

6. Prevent searching for materials which are ordered but not yet received.

The purpose of M control (What has been done) is to provide managers and supervisors with a tool that will exhibit deviations from the plans and schedules in order for them to take corrective actions.

3.4 Stores and Procurement

"We do not have parts when we need them", is one of the most often heard complaints from the M staff. If a M crew has to wait for spare parts and materials it does not only delay the time required to bring

machinery and equipment back to operational performance. It may also create irritation amongst the crew, in particular if it works under an incentive system. The anticipated bonus may be reduced. The crew may have to change to another job. And when the missing part has come, the crew may rush back. This is against all accepted rules of job satisfaction.

It is, of course, not feasible to keep all parts and materials in stock. What to keep in stock and how much can be decided through simple calculations. It must be a part of the planning and scheduling not to start any M job without checking the availability of parts and materials with the store departments.

3.5 M-shops, M-tools and M-methods

The same systematic thinking which is used in a layout for a production department can, and should, be used when organizing an M shop. Consideration must be given to flow of machinery and equipment when it comes for repair or overhaul: Space for disassembling, cleaning, intermediate storage, reconditioning, testing, painting etc etc must be properly arranged for. Where should the facilities used for reconditioning be placed? What can be stationary and what must be mobile? What tools can be readily available and what tools must be kept under lock and key and so on? Should each M worker have a set of tools selected to suit each ones particular needs in accordance with the type of M jobs attending to?

The systematic thinking should also be applied to individual workplaces in the M shop, in particular when certain M operations are of repetitive nature.

The M methods should be as standardized as possible. The MTM (Methods Time Measurement) system and related systems can provide valuable assistance in building up standard methods and data. It is not uncommon that large industries in Europe and the US have around 80 % of their M work covered by effective standard methods and standard times. The significance of this for introducing I are obvious because we then have norms on which to base the actual performance.

3.6 Trained Manpower

The manpower engaged in M must be well qualified within their respective crafts. They must be well informed about the objectives and scope of their work as well as the M function as a whole. And they must receive regular upgrading in order to be able to handle more and more sophisticated machinery and equipment.

When a special efficiency or I scheme is introduced, the M workers must receive detailed orientation about its purpose and training in its application.

4. ELEMENTS OF JOB MOTIVATION

The problems and questions of job motivation have long attracted the interest of many people in the industrialized countries, as a natural consequence of the evolution in these countries, where the basic needs have been overcome.

Much research has been done, but many questions remain unsolved when it comes to making definite rules for man's motivation to work.

The prospects of making more money has so far been the major stimulus for motivating man to do more and better work. Very little of modern motivation theory has yet been systematically incorporated into industrial incentive systems. Most of what has been done is for salaried personnel and of an experimental nature.

As most of the developing countries have not yet run into these problems, we shall only briefly mention a few of the elements.

Without going into details it is felt that even with the differences in motivation in the industrialized and the developing countries, it should be stressed that there is more to motivation than can be rewarded by I plans. Such motivational factors are mainly: Supervision, job contents, job level, specialization, influence on decision making and knowledge of results, work group relationships.

The needs that are usually taken as the starting point for motivation theory are according to the American Social Psychologist A. H. Maslow the so called physiological drives. The human being who is missing everything in life will hunger for food, water somewhere to live with his family and the like, rather than safety, esteem and knowledge. As long as the problem for the individual is to cover his basic needs, his thoughts will be focused on them. To cover basic needs primarily motivates him to work - it is survival of the fittest.

When his basic needs are satisfied, other and "higher" needs tend

to play a greater role to him. The physiological - basic - needs are still there but not so dominating. The needs for safety come into the picture. The safety factor includes coping with elements as medical and dental care, unemployment, disability, old age as well as security for the family.

If both the physiological and the safety needs are satisfied, the next "higher" needs that will emerge are the belongingness and love needs. The person will now feel keenly the absence of friends, a wife and children, i.e. he will hunger for a place in his work group.

The esteem needs are the next ones to appear. All people in society have a sound drive for self-respect, usually high evaluation of themselves and also for the esteem of others. To self-respect belongs a wish to perform something, to develop, to be competent and well educated with a specific field and also to have a certain amount of independence. The person feels he has a function and is esteemed in society.

When looking at the sequence in which Maslow puts the needs that form the motivation one may not agree and it is also still let to prove whether or not this theory can be transferred to the developing countries. The theory is built upon man's situation in dynamic societies, we do not know if it applies to man in static societies too.

When the basic needs are overcome the environmental conceptions may strongly influence man's motivation thus bringing cultural and religious aspects of the different countries into the pattern.

PRINCIPLES AND METHODS FOR SOUND I PLANS

The design and subsequent installation of an I for M plan must follow certain principles and requirements:

Design of plan. Make a detailed demand analysis before starting on the design. What is expected from the I plan? What is the company willing to invest in installation costs such as: setting time standards, orientation and training of personnel, required physical and organizational changes etc? What is the company willing to spend on recurring administrative costs to operate the plan? What savings can be expected? What is the expected lifetime of the basic data and the application model? A demand analyses will indicate the correct level of aspiration to aim at.

Establishment of standards. Firm standards covering most parts of the work for the crafts involved must be established before the plan is fixed. Standards should not prove to be too loose, nor too tight, shortly after the start of the plan. Revising standards too soon after implementation may have bad effects on the M workers. It is not necessary to cover all M crafts from the very beginning.

Correct reporting. A correct reporting and control system must be operational at the same time as the I plan is put in force because it must be known:

- if any standard is too loose or too tight,
- if the standards are applied correctly,

and because:

- facts and figures may be useful in labour union negotiations,
- facts and figures are required in the M information system.

Revision of standards. Methods and means for revision of standards must be built into the system already during the design phase. Production equipment changes very fast in an industrial world with rapid technological development. There is a similar development of M methods, tools and equipment.

Acceptance by everybody involved. Three groups have to be taken into confidence during the design phase in order to obtain a positive attitude and co-operative spirit. These groups are the workers, the supervisors and, if standard data are used, the applicators - the individuals who apply standard data in order to estimate job standards. The introduction of an incentive plan in the M department will not only change working conditions for operators but also the tasks for foremen and supervisors. Resistance against change can be a problem and an extensive training and orientation program must therefore be an integrated part of the implementation plan.

H. B. Maynard, one of the fathers of advanced management, summarizes in his Industrial Engineering Handbook the characteristics of a sound wage-incentive plan as follows:

1. There must be a direct relationship between something of value which is measured (frequently output) and the performance in terms of the measure.
2. It should be simple enough for each employee to understand readily and to compute his own incentive pay.

3. The standards upon which the wage-incentive plan is based should be accurately established by thorough engineering analysis and, whenever pertinent, by time study.

4. The plan should provide for the changing of production standards whenever changes in methods, materials, equipment, or other controlling conditions are made in the operations represented by the standards.

5. Standards should be guaranteed, however, unless changes occur which clearly alter the work measured.

6. To be effective, the plan should be sufficiently generous to convince workers that they are being adequately repaid for turning out good work more rapidly.

7. It should be unrestricted as to the amount of earnings. However, no wage-incentive plan can continue to be effective very long if high earnings can be made without a high output of effort.

8. Under ordinary circumstances, management should guarantee that the employees' basic rates of pay which existed prior to the plan will become minimum rates of pay under the plan.

9. In fairness to owners and consumers, the plan should usually result in a reduction of the unit factory cost of manufacture, making lowered prices possible.

10. Desired simplicity of records will be achieved when labour cost remains unchanged at any level of output in excess of that established as standard.

11. The plan should be so established that it may be related readily to other management controls, such as quality control, production control, or cost and budgetary controls.

12. In general, the plan will be most effective when applied to individuals or small groups rather than to large groups.

13. The plan should have the continued attention of those directly responsible for its operation and the continued attention and support of top executives.

14. The plan should be fair to employees, managers, and owners in its establishment and in its administration.

15. Definite instructions covering policy and method of operation should be provided so that the plan may be maintained.

16. Management and employees or their representatives should be in real agreement as to the adoption or modification of the incentive plan.

And Maynard also gives the following advice as to pitfalls that should be avoided in establishing and operating a wage-incentive plan:

1. Failure to fully inform employees and their bargaining agents regarding plans and proposed procedures in establishing incentives.

2. Failure to have supervision play a major role in the setting-up of incentive plans.

3. Failure to recognize the caliber of men and the high level of competency required to establish and maintain wage-incentives properly.

4. Failure to take into account, analyze, and establish standards for materials and spoilage or bases whereby there is a clear understanding that incentive payment applies only to the production of acceptable work.

5. Failure to properly and continuously maintain measured standards and wage-incentives once they have been established. The operation of an incentive plan over a period of time is fully as difficult - probably more difficult - than its design and installation.

6. The practice of setting a temporary standard in new plants or on new operations should be kept to a minimum. In any event it should be clear to all that the standards are temporary for a relatively short period of time.

6. M PERFORMANCE MEASUREMENT

6.1 M operation time

For years, industrial engineers have been trying to find ways of developing accurate standards for maintenance work, following the same approach as used in measuring production. They have been trying to set standards which would represent the exact time required by the qualified maintenance worker to do each job. Not only is this very costly and time-consuming, but it ignores one of the basic characteristics of maintenance work - the wide variety of conditions encountered. Engineers always asked how they could set an exact standard on, say a pipe repair job when they could not tell in advance how

badly the pipe was rusted. Once it was accepted that this was actually impossible, the foundation of the UNIVERSAL MAINTENANCE SYSTEM (UMS) started to take shape. It was realized that it was feasible to say that a given job could be performed within a "range of time". For instance, while it was not possible to say that changing a bearing on a press would take exactly 3.1485 hours, we could say with certainty that it would take somewhere between 2.5 and 3.5 hours.

Working on this principle, The Maynard Group has built up a library of data on maintenance work, covering all trades and most industries. The standards represent the time required by an average craftsman to do a job under normal conditions using a good method - not necessarily the method that has been used in the past. One standards "applicator" is required for about twenty craftsmen. The craftsman's performance, and hence his bonus entitlement, is not measured on a single job, but over a period of, say, a week.

Using the "range of time" concept, managers can easily develop standard job times for representative or bench-mark jobs and have them catalogued in a series of standard work groupings by type of craft involved and according to the range of time or work group into which they fall. These time ranges are illustrated by the standard work groupings and work group times as shown below:

Time Group	Standard (median hours)	Time Range (Hours)
A	0.1	0.00 - 0.15
B	0.2	0.15 - 0.25
C	0.4	0.25 - 0.50
D	0.7	0.5 - 0.9
E	1.2	0.9 - 1.5
F	2.0	1.5 - 2.5
G	3.0	2.5 - 3.5
H	4.0	3.5 - 4.5
I	5.0	4.5 - 5.5

When a catalogue of reasonably accurate bench-mark jobs has been developed, the next step is to compare the work content of a given job with the work content of a job already in the catalogue. When there is an appreciable similarity in this work content, the same work group time can safely be used.

The development of standards is rather complex if it has to be done from scratch. However, there are thousands of bench-marks from all types of industries available which with very little effort can be validated to fit any plant. Revision of data is often facilitated by computer programs.

When a data bank for bench-mark jobs has been developed, this can be used as the base for incentives in a wide variety of ways.

6.2 Production output

In some cases it is also possible to measure M performance through production output.

Comparing the number of M hours with a fixed base (i. e. production output) is one way to indicate an efficiency. It is, however, hard to avoid influence from changes in sales or from shortage of material.

Comparing the number of M hours with an input/output relation is also difficult to measure with decent accuracy and also in this case to avoid influence from irrelevant factors.

The performance may also be expressed as the reduction in down-time (hours or %) registered. As this includes only a limited part of the total M work it is not a clear cut expression for M performance. It may, however, be used as a temporary measure because it can be installed quickly.

6. 3 Merit award

In a merit award system management determines to underline certain aspects of the workers' knowledge or behaviour by relating them to factors in an evaluation system. The system must consequently be taylor made to each company. Examples of merit award factors are:

- Knowledge of work and work experience
- Quality of job performed
- Application to job
- Co-operation
- Attention to safety
- Care of materials, equipment and tools

Each factor carries usually a certain weight. A committee of supervisors, foremen and perhaps also a labour union representative periodically reviews each M worker in respect to the award scale. The individual's number of points are converted to the amount of money he will receive until the next review.

Unfortunately, the design of the system means that reward for good performance comes too late to have a motivational effect on the worker. The correct selection of factors and their weight can be discussed and the supervisors are seldom experienced enough to make reasonable correct assessment of the factors. Although the first results when implementing merit awards are often encouraging, the system is not really to be recommended. The reason for this is that worthwhile results can seldom be sustained.

6.4 Other methods

Some companies use work sampling in measuring M efforts. Combined with improvement steps in other areas, work sampling has been useful in indicating trends. Also, it can be exceedingly useful for highlighting areas where improvement is required and then for indicating the amount of improvement that is achieved. However, it offers no real measure of the actual performance or effectiveness of people, only indications of the way things are going. It does not measure the work with respect to skill and effort applied to the job or the adequacy of the methods used.

7. I PLANS

Based upon the different M performance measurement methods previously described, a wide variety of I plans can be developed. M work and I plans can be broadly classified and grouped in the following way:

	M work		I plans and base for bonus
I	M workers attending chiefly to scheduled and pre-planned M and repair either in an M-shop or in a production department.	1 2 3	M operation time Production output Merit award
II	M workers assigned to specific areas or equipment, and acting as trouble shooters and attending to numerous small M and repair jobs. Supervision mainly from production department.	4 2 3 1	Work load bonus plan Production output of group serviced Merit awards M operation time
III	Service personnel such as storekeepers and tool room attendants with intermittent work requirements.	2 1	Merit awards Bonus based on efficiency on area or group serviced

The figure establishes a relationship between types of M work and the basic approaches to I plans. We will now investigate some interesting I payment schemes more in detail.

7.1 I based on operation time

I based on operation time usually have a strong motivational effect. They are best used on M work group I. They are hard to measure and follow up in group II if most of the time is assigned to trouble shooting.

A. Actual performance is measured against standards. Incentives usually start at 100 % performance (sometimes lower) and wages rise as performance goes up. A typical pay formula could be:

$$\text{Total pay} = B + B\left(\frac{\text{time allowed - time taken}}{\text{time allowed}}\right)$$

where B = Base wage and "time allowed" is compiled from the standard data system.

The base wage can be determined in three different ways:

1. Individually for each worker through merit award system,
2. Be fixed for all workers or,
3. Be grouped after, i. e. years with the company.

B. An alternative to the plan above is the following formula:

$$\text{Total pay} = B\,\frac{\text{time taken}}{\text{time allowed}}$$

Here the total pay is highly influenced by the workers' productivity. To even out variations, which are hard to avoid in maintenance work, the productivity could instead be measured on a work group, i. e. the M people in a certain production department.

C. A more rough approach is to measure productivity of a work group, divide productivity into three sections and measure say 10 % of all jobs against standards. Each productivity section has its own wage rate and the work group consequently can receive only one of three wage rates each period, dependent upon which productivity section this work has been assigned to through the measurement against standards.

7.2 I based on production output

This method can be used in all the groups I, II and III. It fits best to a trouble shooting group and for service personnel where we otherwise have a measurement problem. Production output or input/output relations could be measured in a wide variety of ways. Here follows some suggestions.

A. This plan includes all direct and indirect personnel influencing production output.

Base wage can be determined in the same way as under 7.1.A.

The bonus received is dependent on the production volume approved. The total wage then amounts to:

$B + B \times f \times$ production output approved

where B = Base wage

f = A factor assigning a relationship between wage and output.

For instance:

f could be 0, 0001 if production is under 1 000 tons
f could be 0, 00015 if " " " 1 100 tons
f could be 0, 0002 if " " " 1 200 tons

The motivational effect of such a plan is not as strong as an operation time system.

B. Service personnel can have bonus on low idling time for the M workers.

C. If the majority of the M workers are covered by direct M work measurement and are receiving incentive pay, some provision must be made to avoid pay-differential problems among assigned M personnel, service personnel and the scheduled direct M personnel. In some instances, the assigned personnel could be the better craftsmen and yet receive less pay. The same problem exists with service personnel. If other M workers receive incentive bonus, it is necessary to provide a method to increase their earnings with incentive pay. There have been various plans to measure storeroom work etc but none has proved very successful. The most satisfactory arrangement to avoid pay discrimination is to pay a bonus based on the efficiency of the M workers serviced. The assumption is that the store's attendant will give prompt service to help M worker reaching a high efficiency by avoiding delays caused by careless servicing.

D. Trouble shooters can have bonus on low equipment down-time caused by machine troubles. Work load bonus plans are also

often constructed according to this philosophy.

E. Equipment utilization and maintenance costs can be favourably influenced by this plan:

$$\text{Total wage} = B + f_1 \frac{\text{equipment time scheduled - breakdown hours}}{\text{equipment time scheduled}} +$$

$$+ f_2 \frac{\text{maint. cost budget}}{\text{maint. cost outcome}}$$

"Maintenance cost" can be substituted with "Maintenance labor cost".

Where B = Base wage

f_1 and f_2 = factors defined in the same way as under A above.

There are a great variety of different possible wage solutions under each of these plans, and all details must be prepared at both country and plant level.

7.3 I based on merit award

A pure merit award system is not recommended. I can, however, be used as part of an I system based on e.g. operation time. The system described in 7.1.A. is an example where the basic wage rate can be determined by a merit award system.

7.4 Individual or Group I

Most incentive plans can operate with either group or individual payments, without upsetting the basic plan. It is just a question of distributing incentive earnings.

When making the choice between the Group and Individual I plan, the following points are considered in favour of the Group payment:

1. Group payment average earnings so that the total pay maintains virtually the same position from period to period,

2. Group payment average earnings so that each employee in the same craft receives the same incentive pay,

3. Group payment average difficult work with easy work,

4. Group payment may be extended to cover all hours - even those without standards (nonrated productive workers, sweepers, toolroom attendants, etc),

5. Group payment simplifies the administration of the plan.

There is a risk though that the group-payment system will result in a failure because:

1. It can be a compensation for potential errors or inefficient management,

2. Individuals or small groups feel they are "carrying" less efficient fellow workers,

3. Individuals or small groups feel they contributed more incentive earnings to the common "pot" than toolroom attendants etc who are included in the same plan.

The following points are advanced in favour of individual incentive systems:

1. Each employee receives pay in proportion to what he produces; high producers tend to produce more and low producers have the incentive to continually improve,

2. High producers receive high earnings which are not to be shared with low producers,

3. Individual incentive can be basis for the foreman to appraise the efficiency of each employee.

With these qualities the individual-incentive plan tends to promote a higher individual performance level than the group plan.

We think that, when making the choice, first preferance should be given to group payment. That is because the most important advantage of group payment is in promoting teamwork, to maintain a level of quality and to stimulate mutual assistance on jobs. If group incentive payment is installed together with well developed control functions and accurate, properly maintained standards as basis of the incentive standards, a group plan achieves the best total result in the long tun.

7.5 Recommended I plans under conditions in developing countries

In accordance with previous chapters we again stress the necessity that an I system for M work must be based upon a good organization and the I plan has to follow the principles in the summary of chapter 5.

As the ideal I plan that fulfils everything desired has still to be found one has to compromize.

In our judgement the following should be covered in an I plan for M workers in developing countries:

A. Individual base wage rated against a merit award plan.

B. Group application of bonus to promote team spirit and high quality level

C. The bonus cumulative period should be one or two weeks - not more.

D. The bonus accumulation should be gradually reproduced in a graphic way, e. g. on a "thermometer" in order to be understood by workers who may be illiterate.

E. The bonus must be based on measurable criterias that can be pre-estimated. The more advanced industries are recommended to implement the advanced operation time systems used in Europe and North America. An organization that cannot meet the prerequisites of such a system might very well start out with an I plan based on production output.

Such a plan could be designed in the following way:

Total wage = $B + B_1 + B_2$

Where: B = Base wage

B_1 = Bonus for meeting production output estimates

B_2 = Bonus for achieving desired production over estimates

8. I PLANS FOR SUPERVISORY AND MANAGERIAL M STAFF

It is extremely rare that supervisory and managerial staff participate in an I plan for M in the more highly industrialized countries. The information and control system will provide top-management with data required to assess over-all performance as well as performance of different departments and activities. And top-management will review the performance with those responsible, appraise performance above desired standards, and discuss remedial actions in cases where performance is below standard. This contact and joint review is considered an important part in top-management's function in coaching, educating and motivating sub-ordinates.

This top-management function is hardly less important in developing countries, and cannot easily be substituted by any I plan.

If, however, one wants to apply an I plan to supervisory staff performance it is of course possible, as long as certain prerequisites are fulfilled. First of all, and whether the plan is related to output or costs, the supervisor must be able to influence the results in an appreciable way.

The Industrial Engineering Handbook by H. B. Maynard gives the following rules:

To be properly included under an incentive-pay system the supervisor should:

1. Have the responsibility for costs properly assigned to him as part of his over-all job responsibility. If this is assigned to him through the level of a formal position analyses, so much the better.

2. Be able to exercise significant influence on the costs of his department's operation by virtue of increasing his skill and effort in managing.

3. Have a sufficient amount of controllable cost in his area to make the application of an incentive plan worthwhile to the company and to him.

4. Be assigned to an area of responsibility which corresponds to an accounting reporting area, so that his performance can be measured by the regular system of cost reporting.

The elements of a sound incentive plan for foremen are quite similar to those of any good wage-incentive plan. A plan must be:

1. Spelled out in the form of a policy and procedure manual.

2. Easy to understand on the part of the foreman, simple in design.

3. Easy to administrate, it should avoid high clerical expenses in calculation of performance and pay.

4. Designed to reflect directly in higher incentive-pay the extra effort and accomplishment by the foreman; it should contain enough incentive-pay possibility to evoke active interest.

5. Able to reflect a reasonable relationship between effort (cause) and cost improvement (effect); the foreman must be able to see the results of his endeavour and to evaluate the results in terms of his improved performance.

6. Designed to promote teamwork among the supervisory group and

not cause competition among the foremen at the expense of the over-all good for the company.

7. The plan should promote the "consultative" approach to management: the plan should evoke the attitude of "how can I help you to do a better job?" from the foreman's immediate superior.

8.1 Managers

An increasing number of firms have been installing salary-evaluation plans for managers and staff personnel. Salary evaluation is of course not a universal procedure, especially not for higher levels of management. On the other hand, as a very big number of companies are using these procedures, it is a good indication that they are worth major consideration.

9. ACHIEVEMENTS

In this chapter we will make a brief description of typical results achieved from implementation of I for M work in two different industries.

Case I. A paper and pulp mill.

Before the plant manager decided to invest money in increasing productivity in his M department, a study showed that utilization was about 60 % and performance about 85 % compared to standard data performance.

This meant a productivity of 60 % x 85 % ≈ 50 % with a total crew of 150 workers.

The implementation of I was preceded by a thorough overhaul of the M organization and sub-projects were carried through covering the following areas:

a. Organizational structure
b. Training and information
c. Preventive maintenance
d. Stores and transports
e. Work order system
f. Planning and scheduling
g. Management control system
h. Tools and equipment

Standard data incentives were installed according roughly to plan 7.1.A. in previous chapter.

One year after installation a new study showed the results derived:

Utilization had increased from 60 % to 78 %

Performance had increased from 85 % to 110 %

Thus productivity was now 78 % x 110 ≈ 86 %

Productivity increase equalled 72 %

This means that while the plant expanded its production output from 200 000 tons/year to 340 000 tons/year in connection with a plant enlargement, they could maintain their original crew size. At the same time they obtained a higher level of maintenance quality.

Case II. A weekly magazine printing plant.

In this company M costs increased steadily and they were having more and more difficulties to overcome delays due to break-downs in the production equipment.

To promote higher efficiency out of their M crew of 101 workers, they started a program with the same sub-projects as in case I. An I plan was installed and within 2 years results were evident.

Although production output had increased roughly 10 percent, the M crew had decreased from 101 to 81 workers and the printing plant had virtually no delay troubles caused by break-downs any more.

10. NATIONAL INTERESTS IN M

When a country has comperatively limited domestic manufacturing resourses, as is the case in most developing countries, it is self-evident that everybody concerned with the well-being of the National Economy is interested to see that all installed manufacturing capacity is utilized to the maximum possible extent.

This manufacturing capacity is established under conditions that are characterized by limited financial resources and have most often caused heavy expenditure of scarce foreign exchange. An optimal return on this investment is in the National interest of any government, government department, government organization and industrial association.

M is, of course, only one of many factors that influences the optimal utilization of installed capacity within a manufacturing enterprise or a service industry. Capacity may be idle because of lack of orders, lack of material and supplies, poor management which may result in poor production scheduling and control and so on, and so forth. Some factors are more tangible than others and some factors may be of far greater importance to the overall utilization than M. However, when a factory or a part of it is idle because of some of its machinery and equipment being out of order, it is a very tangible reason for reduced utilization. And any other current factor will hide nicely and pleasantly behind the M factor.

It is commonly recognized that manufacturing equipment in general last shorter, and is more idle because of break-downs, in less industrialized countries than in the more industrialized countries. And the countries with a lower degree of industrialization can actually less aford it because their financial situation and their foreign exchange resources in most cases are extremely strained.

In the industrialized countries it is difficult to envisage that maintenance should be dealt with at any other level than the enterprise level. Management of all categories realize that proper utilization of installed capacity is of utmost importance to the productivity of the enterprise.

The environment creating this attitude and understanding does not yet exist in most developing countries. It may therefore be necessary and justified to accellerate an evolution in the right direction.

It should therefore be amongst the objectives of any National industrial policy in a developing country to urge manufacturers to keep plant, machinery and equipment in good working order.

As with other Is, policies and subsidies created to promote rapid industrialization and efficient operations, it should be revised with regular intervals in the light of changing environments. Any subsidy or I that becomes of a permanent nature may upset or delay a healthy industrial development process.

The encouragement of good M for keeping plant break-down to a minimum should not be limited to efforts for the introduction and up-keep of an efficient M system within enterprises. The productivity and in particular the costs of operating a M system is to a large extent affected when the plant is built and the machinery and equipment is selected. A National policy for I on M should not forget this factor. Many M problems in the developing countries have been seriously magnified because machinery and equipment has been installed which was not suited for the prevailing climatic condtions, was not suited for the quality of local operators, repairmen and supervision, was not suited to the repair facilities available locally, was not supported by local stores of parts and components, did not match already existing machinery and equipment and so on. A National I scheme for M must consider these serious problems and encourage a comprehensive approach. And the comprehensive approach should not be limited to the enterprise function such as procurement, production, M and financial control but also to the many governmental departments and organizations dealing with industrial development, import control, technical assistance, finance and investment, technical education etc.

11. ENFORCEMENT OF NATIONAL INTEREST IN M

In most developing countries it is necessary to obtain permission from one or more Government departments or organizations when a party wants to:

a. Establish a manufacturing enterprise
b. Procure machinery and equipment from abroad

This fact provides the concerned National authorities with an unique opportunity to see to it that enterprises are established and/or expanded according to sound economic principles and fixed industrial development policies.

It may cause some discussion to reach agreement on what sound economic principles are and how the policies on industrial development should be. However, this paper is limited to the area of industrial M. What would we, as responsible politicians and civil servants do in order to promote better M?

The subject seems to fall in two part :

1. How can we promote better M in new enterprises?
2. How can we promote better M in existing enterprises?

Design engineers, procurement officers and industrial engineers can provide a lot of criterias that have to be met when we want to operate machinery - and equipment within certain levels of availability and reliability. A number of papers deal specifically with these subjects.

The paper on Maintainability e.g. lists the following major factors that effects availability and reliability:

- Design characteristics
- Operational characteristics
- M manpower qualifications
- M organization
- Repair shop facilities
- Spare parts logistics
- Inspection and test equipment
- Tools and methods
- Manuals and handbooks

The desired level can be expressed in terms of one ore more criteria like:

- Operability of machinery and equipment
- Time for M
- Cost of M
- Risk of injury to personnel
- Time required for training

What can politicians and civil servants then do about M when they institute policies on establishment of enterprises and when they screen schemes submitted? The answer is easy - at least in principle:

a. Policies must be based on sound technological and financial principles

b. Schemes must be evaluated in the light of established policies and criteria.

In real life, however, it is extremely intricate because it is difficult to spell out and agree on policies and criteria that are detailed enough to be of practical use and it is difficult to recruit local manpower that has the qualifications and the integrity to exercise the evaluation.

And what kind of I can be introduced to encourage everybody concerned to follow established policies and to meet M criteria?

Who should participate? How should the I be calculated? What should the base be? Is it realistic to think of an I scheme for M for politicians and/or administrators? In most cases the answer is No.

This does not imply that one should not try to educate and upgrade everybody concerned with M. The aim should be to promote broad and balanced looks and consideration of overall efficiency rather than that of a single element, e.g. purchase price or power consumption.

Much can be said about the problems that confront officials concerned with industrialization in a developing country. Funds for investment are in short supply. What kind of industry should receive priority? Procurement may have to be made from countries or suppliers who offer grants or loan on easy terms. Will the machinery and equipment suit local conditions? What will it cost to operate the factory? What will the cost of the product(s) be? Who can distinguish the interests of the supplier from the ambitions and needs of the buyer? And who thinks of M?

It is recognized by well established suppliers of industrial machinery and equipment that their continued success depends on the satisfaction of those who use their products. Developing countries could most

probably make extensive advantage of this fact. It should be possible to introduce a rating system that would evaluate the performance of machinery and equipment and collect the data centrally. If the rating is below a certain level, it should have an impact on import licences.

Several suppliers and importers may object to this and, with some rights, claim that the operability of machinery and equipment depends on a wide variety of factors including several on which they have little or no influence, e.g. poor operators, poor materials, fluctuations in electric power supply, unauthorized lubricants or spare-parts. Many of these factors can be compensated through instruction and training as well as after-sales service and follow-up. Suppliers and importers that can provide this, or assist National efforts (e.g. technical schools), should receive preferential treatment. A reasonable choice of spare-parts should be placed in consignment stores so they are readily available. Optimum standardization should be aimed at in order to keep stores within reasonable limits.

The major problem with an I scheme of this kind lies with its administration and the reliability of the data on which to base it.

12. CONCLUSIONS

I systems are an integrated part of renumeration systems and designed in order to stimulate participants to extra efforts through an award that is related to the performance.

I systems, and in particular wage I systems, are well described in the

litterature related to industrial management and industrial engineering. They can be applied to all kind of manufacturing and service activities. In principle there is not much difference between their application at the plant level in developed and under-developed countries. The main difference comes from the environments and the educational level of the individuals involved, in particular their ability to receive, interpretate and dispatch exact information and data in writing.

In environments where there is no or little tradition for I systems, e.g. in repetitive production work it is difficult to introduce I schemes for M. If introduced, they must be simple and easily understood. The best results may be achieved through I schemes covering first line supervisors.

It is tempting to think of I for M at the country level, but it is difficult to establish standards on which to base an I plan, in particular for Government officials. As most M problems can be anticipated at the procurement stage, efforts should aim at a careful technological and financial examination of the criteria used for selecting machinery and equipment.

Importers and suppliers play an important role in this process and in backstopping M activities. The efficiency in these respects can be evaluated, and hence stimulated through increasing licences to those who are most successful.

Industrial associations can arrange special M campaigns at regular or irregular intervals. Enterprises may compete on the basis of who can reduce M costs the most, or who has the least break-down time in relation to productive time etc. etc. Awards can be financial or just honourable.

I is normally one of the last, if not the last, management tool used to increase productivity. Much can and should be achieved through improving the organizational structure and by simplifying methods and procedures.

The establishment of sound policies and the design of useful I for M in developing countries requires a lot of imagination and hard work.